Burrowing behaviour and burrow architecture in *Apodemus sylvaticus* (Rodentia)

By K. Khidas and M. H. Hansell

*Laboratoire de Mammalogie, Unité de Recherche en Biologie et Agro-foresterie,
Université de Tizi-Ouzou, Algeria, and Zoology Department, University of Glasgow, Scotland*

The commonest kind of home constructed by mammals is a burrow. The order Rodentia comprises the largest concentration of burrowing species. The burrow is therefore an important part of the biology of rodents which needs to be understood in terms of both its construction and function.

Little is known about burrows and burrowing behaviour in *Apodemus sylvaticus*. A few studies have reported that this species has a burrow system consisting of a dwelling with distinct architectural features constructed by a single individual (Dufour 1971, 1978). The architecture of this system as dug in the natural habitat; was described from a small sample by Jennings (1975). It was found to consist of separate nest and food chambers usually well protected under the base of a tree, joined by a tunnel in the form of a loop giving access to between three and six radiating exit tunnels. Similar observations were previously reported by Cleminson (1966) from the wild. The burrows, apart from providing some benefits, are areas where interactions between individuals may be concentrated and intensified (Montgomery and Gurnell 1985).

The purpose of this study was to examine the burrowing behaviour of *A. sylvaticus*, a species with an extensive western Palaearctic range (Corbet 1978), in a laboratory environment to examine the details of burrow architecture, how burrows are created and how long they take to complete.

Twenty four sexually inactive adult wood mice *A. sylvaticus* (13 males and 11 females) were used in this study. The animals were caught using baited Longworth live traps in Garscube and Loch Lomond areas near Glasgow, Scotland. The respective mean body weights for the males and the females were 22.3 ± 2.6 g (range: 17.8–28.2) and 19.2 ± 2.6 g (range: 15.6–23.8). The mice were housed individually in plastic cages ($15 \times 27 \times 13$ cm). Lights were set on a 12:12 light-dark cycle and temperature varied between 21 °C and 23 °C. Mice were submitted to a period of acclimation of at least 6 weeks to these conditions before the onset of any test.

A terrarium ($1.5 \times 2.0 \times 1.0$ m high) made of 1.0 cm thick plywood panels and divided into two equal parts (1.0×1.5 m) was used. The top was covered with a wire lid. A perspex window (0.5×2.0 m) was fitted on one side to allow incidental observations. Dry food and water were provided in small containers placed in a corner. The terrarium was filled with a flattened 10-cm layer of fine yellowish wet sand to allow the mice to burrow. In order to simulate a natural tree or rock, a wooden box ($0.4 \times 0.4 \times 0.2$ m high), with two opposite sides parallel and sloping at an angle of 45° was placed on the surface of the sand in the centre of each of the two compartments.

The mice were tested in two test sets: one of 24-hour and the other of 72-hour duration. Subjects were placed individually in the terrarium approximately 30 min before light offset.

The whole burrow system was revealed by excavation. All traces of mouse activity on the surface and complete portions with all details of the burrows were accurately mapped at a 1:5 scale on graph paper using a grid divided into 5×5 cm multiple squares drawn on a 0.5×1.0 m plastic sheet, and placed on the surface of the sand. Depths were recorded every time the slope changed.

After each set of records and before another mouse was tested, all of the sand was mixed and when necessary moistened, and the walls washed in order to remove any scent marks. The sand was replaced periodically throughout the test.

Mice burrowed very readily under the controlled conditions. Except for one mouse, all the others had dug at least one burrow of greater or lesser complexity. There were always mounds of excavated sand at the initiation entrances, well more frequently one mound per burrow system. Thirty-two burrows were constructed. Two types were recognised: simple tunnels and main burrows.

Eight simple tunnels were recorded. They consisted either merely of a dead-ending tunnel with an entrance aperture or of two apertures connected by a single tunnel. Their mean total length was 17.4 ± 9.8 cm (range 7.0–37.5; n = 8) and maximum depth 6.4 ± 1.7 cm (range 3.8–8.5; n = 7). Four mice dug such burrows. This type of excavation did not have any obvious function, except that one simple tunnel constituted an underground food cache. It was always found associated with main burrows.

Twenty-four main burrows (75%) were constructed (Tab. 1). Six of them (19%) consisted of one entrance hole followed by a tunnel joining a chamber, and an escape tunnel connecting the chamber to the surface. One junction of tunnels was recorded (Fig. 1 a). The others (56%) were more sophisticated. They contained one or several entrance and exit holes associated with several tunnels, among them "chimney" tunnels which serve as escape passages, one or two chambers, usually several junctions of tunnels, loops and store chambers and tunnels (Fig. 1 b and c). One female constructed two burrows of this type, one of the basic architecture and the other of the latter kind. Few of the burrows (29%) reached the bottom of the terrarium, and only an overall distance of 50.5 cm (2%) was dug against it. Resting chambers were generally the deepest part of the burrow. Nineteen burrows had only a single chamber, and five contained two chambers. Several exit holes (33%) were not yet popped; small cracked bulges appearing on the surface revealed their presence. Many other accesses (21%) and an overall distance of 73.5 cm (2.7% of the total length) of tunnels were plugged with sand. In four burrows the whole initiation entrances were blocked and left unused; they were very likely plugged while the animals were progressing in tunnelling. Most (63%) of the dead-ending tunnels were like the escape tunnels directed upwards, almost vertically at their end, to the surface. They stopped, however, at a distance of 3.2 ± 1.8 cm (range: 0.5–6.9) from the ground level. They very probably serve as latent escape passages.

Table 1. Mean ± SD and range of parameters of the 24 main burrows constructed after 24 hours. The measurements are computed from each single burrow. The 0 score of the failed male was not included in the analysis. Tunnel lengths were calculated from the burrow representations on the graph paper. Any dead-ending tunnel of less than 5 cm length, which is assumed as being the minimum space large enough to admit a mouse, was omitted from the computations

Length (cm)	Depth (cm)	Surface (cm2)	Holes (n)	Tunnels (n)	Chambers (n)	Junctions (n)
108.1 ± 50.7	8.3 ± 1.5	559.3 ± 195.0	2.5 ± 2.1	5.7 ± 4.9	1.2 ± 0.4	2.6 ± 2.2
37.5–220.0	5.0–10.0	25.0–600.0	1—12	2–25	1–2	1–11

There was a significant positive linear correlation (Spearman test, r (32 bur-rows) = 0.73, df = 30, p < 0.001) between the length of the burrows and their complexity, burrow complexity being obtained by combining all the architectural features numbers.

The burrows were not randomly located in the terrarium although the space available was quite limited. Nineteen burrows (59%) were wholly or partly located beneath the wooden box. The volume of sand excavated and the space used for burrowing are signifi-cantly larger (total length dug 1 242 cm vs. 1 492 cm, Chi2 = 3 467.05, df = 1, p < 0.001; to-tal surface 6 969 cm2 vs. 7 081 cm2, Chi2 = 22 351.75, df = 1, p < 0.001), and significantly more chambers (17 vs. 12, Chi2 = 69.78, df = 1, p < 0.001) were dug beneath this box than in the area away from it. A signifcantly larger number of initiations of burrows (21 vs. 15, Chi2 = 10.67, df = 1, p < 0.01) and of entrance/exit holes (30 vs. 41, Chi2 = 2.96, df = 1, p < 0.05) was located along the box periphery. Moreover, 11 of the burrows (52%) were initiated and 15 of the entrance and exit holes (50%) were located against the over-hanging side (respectively, Chi2 = 9.28, df = 3, p < 0.025; Chi2 = 10.0, df = 3, p < 0.001).

Males (the failed male is included) and females excavated statistically similar amounts of sand for burrowing. Yet, the female burrow systems each taken as a whole, i.e. simple tunnels when present lumped together with main burrows, showed significantly a higher number of features than those of the males (mean total number of features respectively 17.3 ± 12.2 vs. 9.3 ± 4.5; Mann-Whit-ney U test, U = 37, p = 0.05), differ-ences still appear and approach statistical significance (Mann-Whit-ney U test, U = 39, p < 0.10) if only the main burrows are considered. As an example, one female constructed one burrow which consisted of 12 entrances, 25 short tunnels with 11 junctions, and 2 chambers; the burrow complexity for this indivi-dual, with a score of 50, is the high-est.

Data were recorded from 23 mice. Mice had significantly dug more by 72 hours (mean total length per mouse 142.3 ± 83.7 cm vs. 113.9 ± 52.7 cm; Wilcoxon T test, T = 69, p < 0.01) and the 72-h bur-rows were significantly more sophis-ticated (total number of features 379 vs. 302; Chi2 = 8.7, df = 1, p < 0.005) than the 24-h ones. Yet, 80% of the total length were dug within the first 24 hours, and, consid-ered separately, only the number of holes had significantly increased (68 vs. 96, Chi2 = 4.78, df = 1, p < 0.05). Larger parts of burrows were plugged after 72-hours (73.5 cm vs. 175.5 cm, Chi2 = 41.78, df = 1, p < 0.001).

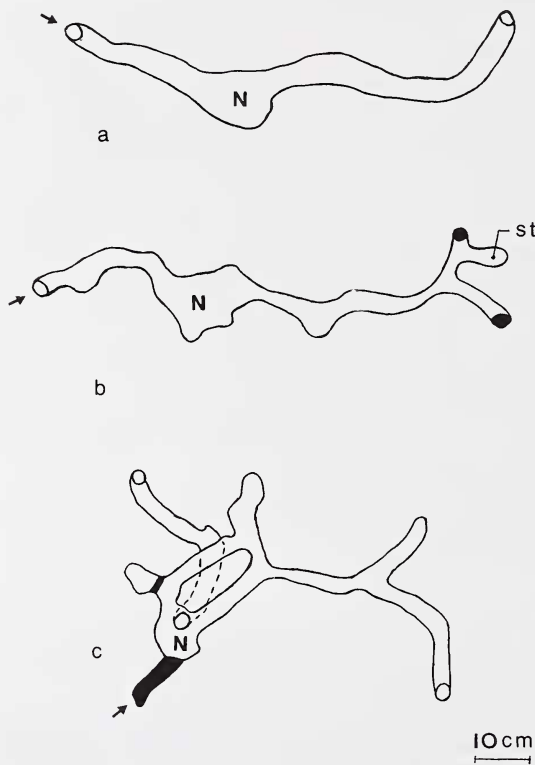The burrow systems constructed by *A. sylvaticus* under controlled

Fig. 1. Topviews of typical main burrows. a: a typical burrow system of the basic architecture; b and c: burrow systems of a more complex architecture. The only com-plete loop recorded is seen in c. The arrow indicates the initiation entrance. N: nest. st: store tunnel. Open circles: open entrances. Filled circles: plugged entrances. Filled areas: plugged tunnels.

conditions contained a nest chamber, a tunnel system with up to eleven junctions, a mean of more than two exits and in some, a store chamber as well. They are comparable with those described by CLEMINSON (1966) and JENNINGS (1975) for the natural environment. The burrow dug by an individual in some cases also included simple short tunnels which could represent a system abandoned before completion. One individual in addition to a complex burrow also dug a simple burrow with nest chamber. This possibly represented an incompletely abandoned system or else an additional home. These observations closely approximate those described by WOLTON (1985) on nest occupancy by *A. sylvaticus* in the wild. This author found that mice changed nest site frequently.

The differences between the burrows built after 72 hours compared with those examined after 24 hours were in certain respects not great. DUFOUR (1971, 1978) reported that wood mouse burrows remained unchanged during the first week with respect to the length and the complexity. During the second or the third week these burrows grew more sophisticated, and their length never exceeded after one month threefold that of the 24-hour burrows. This suggests that a largely completed burrow could be constructed in the natural environment in as little as 24 hours. This, however, assumes that the substrate will be as easy to burrow in as moist sand.

Sex differences in the burrow system were detected, with females creating a somewhat more complex architecture. The mice tested were not breeding but the differences do suggest that when breeding, the burrow system of females may have additional complexity. Albeit, DUFOUR (1978) found from a test on a small sample that the only difference between the burrows of breeding females and those of non-breeding ones lay in the padding of the nest chamber. This deserves further study.

The wooden box placed on the sand surface was highly attractive to the animals. Its position seemed to influence the architecture of the burrow system below ground with more of the burrow system being located under the shape than would be predicted by the area it occupied. This supports the field observations that burrow systems are located at the bases of trees (CLEMINSON 1966; JENNINGS 1975). According to CLEMINSON (1966) chambers in this protected position may be less subject to collapse, or to percolation of water from above. It was also clearly shown that the mice preferred to initiate the burrow along the side which sloped over them. However, from the spoil heaps of excavated sand and the subterranean architecture it was seen that burrow exits/entrances could be created and later closed during burrow construction so that the site of burrow initiation was not necessarily retained as an entrance. In the same way RODE (1929) reported from experiments on *A. sylvaticus* in outdoor terrariums that, except for few holes initiated against walls, all the burrows accesses changed over time. This behaviour and the presence, in our study, of burrows with just their entrance holes stopped suggests that in the natural environment the entrances and exits in current use may change over time possibly to confuse predators. The plugging/unplugging of accesses may also represent a regular behaviour which serves to protect burrows from flooding as observed by HAYNE (1936) in *Peromyscus polionotus*.

In conclusion therefore, this study shows that burrows of *A. sylvaticus* under controlled conditions varied in complexity but were typically similar to those described for mice in the wild. It also suggests that environmental and internal factors modulate altogether this behaviour. The natural architecture could thus change to adapt to local environmental circumstances.

Acknowledgements

References

Cleminson, N. H. (1966): A study of the underground runs of *Apodemus* and *Clethrionomys*. Bull. Mammal. Soc. Br. Isl. **26**, 5–6.

Corbet, G. B. (1978): The mammals of the Palaearctic Region, a taxonomic review. London, Ithaca: British Museum (Natural History) and Cornell Univ. Press.

Dufour, B. (1971): Données quantitatives sur la construction du terrier chez *Apodemus sylvaticus* L. (Mulot sylvestre). Mammalia, Muridae. Rev. Suisse Zool. **78**, 568–571.

– (1972): Adaptations du terrier d'*Apodemus sylvaticus* à la température et à la lumière. Mammalia, Muridae. Rev. Suisse Zool. **19**, 966–969.

– (1978): Le terrier d'*Apodemus sylvaticus* L.: sa construction en terrarium et son adaptation à des facteurs externes et internes. Behav. Process **3**, 57–76.

Hayne, D. W. (1936): Burrowing habits of *Peromyscus polionotus*. J. Mammalogy **17**, 420–421.

Jennings, T. J. (1975): Notes on the burrow systems of woodmice (*Apodemus sylvaticus*). J. Zool. (London) **175**, 500–504.

Montgomery, W. I.; Gurnell, J. (1985): The behaviour of *Apodemus*. Symp. zool. Soc. Lond. **55**, 89–115.

Rode, P. (1929): Contribution à l'étude du fouissement chez les petits rongeurs. Bull. soc. zool. France **54**, 573–588.

Wolton, R. J. (1985): The ranging and nesting behaviour of Wood mice, *Apodemus sylvaticus* (Rodentia: Muridae), as revealed by radio-tracking. J. Zool. (London) **206** (A), 203–224.

Author's addresses: Kamal Khidas, Laboratoire de Mammalogie, Unité de Recherche en Biologie et Agro-foresterie, Université de Tizi-Ouzou, Tizi-Ouzou, 15000, Algeria; Michael H. Hansell, Zoology Department, University of Glasgow, Glasgow G12 8QQ, Scotland.